Lab 6 – Binary Phase Shift Keying (BPSK)

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# **Experiment Objective**

Understand the principles of Binary Phase Shift Keying (BPSK) digital modulation scheme, its error performance through simulation and hardware implementation of BPSK modulation.

# **2.0 About Laboratory Day and Equipment List**

# The laboratory session took place on the Thursday section between 9:00am and 11:50am on March 28th, 2024. My lab partner was Isiah. The equipment for the is experiment is listed below,

1. MATLAB
2. Rohde & Schwarz RTM 3034 Oscilloscope
3. Function Generator
4. 2N4392 NMOS
5. LF351N Operational Amplifier

# **3.0 Simulation**

A diagram of a waveform

Description automatically generated with medium confidence

Manchester Encoding Simulation Results

See Section 5.0 for MATLAB code.

# **4.0 Implementation**

# A screen shot of a computer Description automatically generated

Carrier Signal

A screen shot of a computer

Description automatically generated

Modulated Signal with Demodulated Bitstream

# **4.5 Questions and Results**

How BPSK modulated signal can be detected? Show the demodulation process for BPSK symbols through block diagrams for the case of

• Coherent detection, and

• Non-coherent detection.

# **5.0 MATLAB Code**

Used to generate figure(s)

clear all;

close all;

clc;

Tb = 0.5;

N=500;

Bits = 2;

t = linspace(0, Bits\*Tb, N);

last\_bit = 1;

for b=1:1:Bits

len = N / Bits;

offset = ((b - 1) \* len) + 1;

last\_bit = ~last\_bit;

for i=offset:1:min((len+offset), N)

message(i) = last\_bit;

end

end

subplot(4,1,1);

plot(t, message);

ylim([-0.2, 1.2]);

xlim([0, 1]);

title("Message Signal");

xlabel("time");

ylabel("Amplitude");

%% Generating BSK signal

E = 1;

M = 2;

fc = 10;

phi = sqrt(2)\*cos(2\*pi\*fc\*t);

s1 = sqrt(2\*E)\*phi;

s2 = -sqrt(2\*E)\*phi;

% noise

N0 = (10^(3/10) \* E);

sigma = sqrt(N0/2);

noise\_matrix = randn(length(t), 1) \* sigma;

modulated\_signal = linspace(0, 1, N);

for i=1:1:length(modulated\_signal)

time = t(i);

value = 0;

if message(i) == 1

value = s1(i);

else

value = s2(i);

end

modulated\_signal(i) = value;

end

subplot(4,1,2);

plot(t, modulated\_signal);

ylim([-2.5, 2.5]);

xlim([0, 1]);

title("Modulated Signal (BSK)");

xlabel("time");

ylabel("Amplitude");

modulated\_signal\_with\_noise = modulated\_signal + transpose(noise\_matrix);

subplot(4,1,3);

plot(t, modulated\_signal\_with\_noise);

ylim([-2.5, 2.5]);

xlim([0, 1]);

title("Modulated Signal (BSK) with Noise");

xlabel("time");

ylabel("Amplitude");

%% Demodulation

demodulated\_signal = modulated\_signal - modulated\_signal;

bit\_sum = 0;

time\_counter = 0;

time\_step = (Bits\*Tb)/N;

demodulated\_bits = [];

for i=1:1:length(demodulated\_signal)

time = t(i);

time\_counter = time\_counter + time\_step;

r\_mul\_phi = modulated\_signal\_with\_noise(i) \* phi(i);

bit\_sum = bit\_sum + r\_mul\_phi;

%plot(time, bit\_sum, '.');

%hold on;

if time\_counter >= (Tb - 0.001)

if(bit\_sum > 1)

bit\_value = 1;

else

bit\_value = 0;

end

demodulated\_bits(length(demodulated\_bits) + 1) = bit\_value;

bit\_sum = 0;

time\_counter = 0;

end

end

bit\_index = 1;

for i=1:1:length(demodulated\_signal)

time = t(i);

time\_counter = time\_counter + time\_step;

demodulated\_signal(i) = demodulated\_bits(min(bit\_index, length(demodulated\_bits)));

if time\_counter >= (Tb)

bit\_index = bit\_index + 1;

time\_counter = 0;

end

end

subplot(4,1,4);

plot(t, demodulated\_signal);

ylim([-0.2, 1.2]);

xlim([0, 1]);

title("Demodulated Signal (BSK) with Noise");

xlabel("time");

ylabel("Amplitude");

# **6.0 Learned Objectives**

* XR-2206 and XR-2211
* FSK Modulation
* MATLAB Simulation

# **7.0 Conclusion**

In conclusion, the lab experiment on Frequency Shift Keying (FSK) modulation provided valuable insights into the fundamental concepts of digital communication. Through simulation using MATLAB and practical implementation using equipment such as the XR-2206 and XR-2211, we gained a deeper understanding of how FSK modulation works, particularly in generating modulated signals and demodulating them. By varying frequencies based on message symbols and utilizing phase-locked loops (PLLs), we observed the transmission and reception of binary data efficiently. Despite encountering challenges with center frequency adjustments during implementation, the exercise enhanced our comprehension of FSK modulation parameters and their impact on signal fidelity. Overall, this lab significantly contributed to our knowledge of digital communication techniques and their practical applications.